

1. [Introduction](#)
2. [Connexions Philosophy](#)
3. Using the Connexions Repository
 1. [Site Orientation](#)
 2. [Modules](#)

Introduction

This module provides an introduction to the Connexions Deomonstration and Tutorial Workshop. Learners are provided with a list of additional resources, including email addresses and supporting websites, that they may find useful after completing the workshop.

What is Connexions?

Connexions is a place to view and share educational material made of small knowledge chunks called modules that can be organized as courses, books, reports, etc. Anyone may view or contribute:

- **authors** create and collaborate
- **instructors** rapidly build and share custom collections
- **learners** find and explore content

System Requirements

Connexions currently supports the Firefox (version 3.0 and later) and Internet Explorer (version 6.0 and later) web browsers. Additional third-party plug-ins are required for viewing some content, including MathML. For additional information about supported web browsers, please see <http://cnx.org/help/browser-support>.

Contacting Connexions

There are several ways to get answers about Connexions:

- To ask a question or get more information about the Connexions project, please contact cnx@cnx.org.
- To report a problem with the site, please visit http://cnx.org/bug_submit_form or send an e-mail to techsupport@cnx.org
- To request technical assistance with the site or with authoring in CNXML, please contact techsupport@cnx.org.

- To report a bug or other problem with the site, please visit http://cnx.org/bug_submit_form.

Joining the Connexions Community

We invite you to participate in the Connexions Community by subscribing to one of the following services:

- To view our blog, please visit <http://blog.cnx.org>. RSS feeds for blog posts are also available from this site.
- To follow us on Twitter, please visit <http://twitter.com/cnxorg>.
- To become a fan of Connexions on Facebook, please visit <http://www.facebook.com/cnx.org>.

Connexions Philosophy

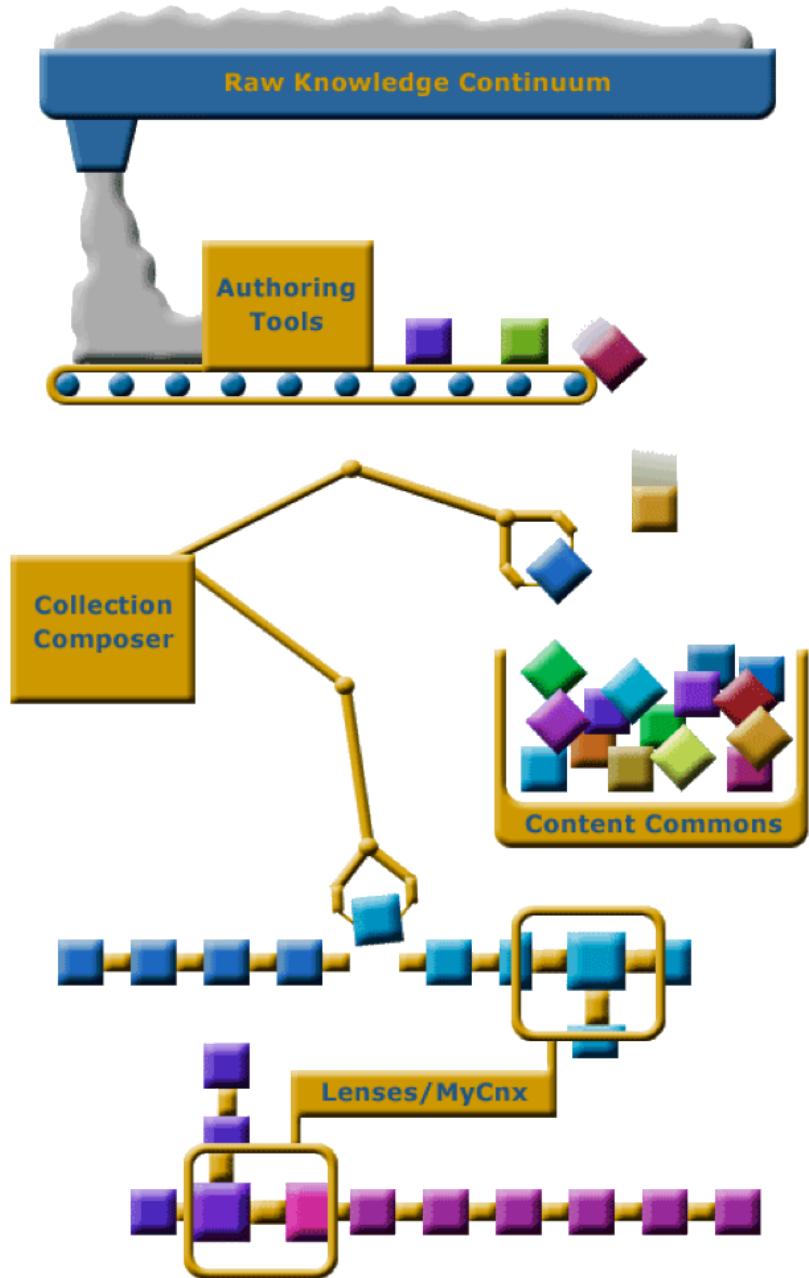
This module provides a CNXML-based version of the Connexions Philosophy page (<http://cnx.org/aboutus/>). It describes our motivation for doing what we do the way we do it.



Connexions is an environment for collaboratively developing, freely sharing, and rapidly publishing scholarly content on the Web. Our [Content Commons](#) contains educational materials for everyone - from children to college students to professionals - organized in small [modules](#) that are easily connected into larger [collections or courses](#). All content is free to use and reuse under the [Creative Commons "attribution" license](#).

Content should be modular and non-linear

Most textbooks are a mass of information in linear format: one topic follows after another. However, our brains are not linear - we learn by making connections between new concepts and things we already know. Connexions mimics this by breaking down content into smaller chunks, called modules, that can be linked together and arranged in different ways. This lets students see the relationships both within and between topics and helps demonstrate that knowledge is naturally interconnected, not isolated into separate classes or books.



Sharing is good

Why re-invent the wheel? When people share their knowledge, they can select from the best ideas to create the most effective learning materials. The knowledge in Connexions can be shared and built upon by all because it is reusable:

- **Technologically** We store content in XML, which ensures that it works on multiple computer platforms now and in the future.

- **Legally**The [Creative Commons](#) open-content licenses make it easy for authors to share their work - allowing others to use and reuse it legally - while still getting recognition and attribution for their efforts.
- **Educationally**We encourage authors to write each module to stand on its own so that others can easily use it in different courses and contexts. Connexions also allows instructors to **customize** content by overlaying their own set of links and annotations. Please take the [Connexions Tour](#) and see the many features in Connexions.

Collaboration is encouraged

Just as knowledge is interconnected, people don't live in a vacuum. Connexions promotes communication between content creators and provides various [means of collaboration](#). Collaboration helps knowledge grow more quickly, advancing the possibilities for new ideas from which we all benefit.

Site Orientation

This module provides a basic overview of the Connexions website in order to familiarize learners with the major site features and navigation system.

Note: See Also: Introduction to Connexions
(<http://cnx.org/content/m10884/latest/>)

No Login Required

You do not need to be logged in to access any of the published content on the site. You can download, view, print, share, or repurpose any content in Connexions for free, without even providing an email address. In fact, the only thing you **HAVE** to have an account for is to **CREATE** content, so we can keep track of whose is whose and make sure to give you credit for your work.

The Home Page

The screenshot shows the Connexions homepage with a blue header bar. The top right has links for Log In, Contact Us, and Report a Bug. Below the header is a search bar. The main content area includes:

- Connexions is:** Described as a place to view and share educational material made of small knowledge chunks called modules that can be organized as courses, books, reports, etc. Anyone may view or contribute:
 - authors create and collaborate
 - instructors rapidly build and share custom collections
 - learners find and explore content
- FEATURED CONTENT:** Advanced Algebra II by Kenny Felder. It's described as a high school math teacher in Eau Claire, Wisconsin, who designed his course using a non-traditional approach to teach a traditional subject. Centered around a Homework and Activities book, along with accompanying Conceptual Explanations and Teacher's Guide collections. Advanced Algebra II tackles topics by focusing on comprehension rather than straight lecture delivery.
- FIND CONTENT:** Shows 14737 reusable modules woven into 763 collections. Includes a search bar and browse options by Title, Author, Keyword, and Revision date.
- CREATE CONTENT:** Shows creating content in Connexions is as easy as 1, 2, 3:
 - Get an account and log in to your workspace.
 - Make a module from scratch or convert it from a Word doc.
 - Publish your works, sharing them with the world.
- MY ACCOUNT:** Includes fields for Username and Password, and links for Get an account and Forgot your password?
- SPOTLIGHT:** User feedback from a man in a tuxedo: "I am a senior vocal music major at the University of Wisconsin-Eau Claire. I attended a French horn recital today, and was surprised to hear French horn players try valveless instruments. As you might imagine, there were several reasons for this, so I decided to investigate about the French horn on the Internet. Your articles on the

The Connexions home page (<http://cnx.org/>)

The following elements appear on the Connexions home page:

Featured Content

The Featured Content portlet highlights exemplary content that shows what you can do with Connexions. New authors may want to use these materials for inspiration.

FEATURED CONTENT

Advanced Algebra II

 The world of second-year algebra comes alive in Kenny Felder's [Advanced Algebra II](#). Felder, a high school math teacher in North Carolina, designed his course using a nontraditional approach to a very traditional subject. Centered around a Homework and Activities book, along with accompanying Conceptual Explanations and Teacher's Guide collections, *Advanced Algebra II* tackles topics by focusing on comprehension rather than straight lecture delivery.

Advanced Algebra II was selected by California's [Free Digital Textbook Initiative](#) to be included in a list of free textbooks available to California schools starting in Fall 2009.

Collaborative Statistics

 [Collaborative Statistics](#) was written by two faculty members at De Anza College in Cupertino, California. This book is intended for introductory statistics courses being taken by students at two- and four-year colleges who are majoring in fields other than math or engineering. The textbook was developed over several years and has been used in regular and honors-level classroom settings and in distance learning classes.

The book focuses on applications of statistical knowledge rather than the theory behind it. The focus is on thinking statistically, incorporating technology, working collaboratively, and writing thoughtfully.

Applied Probability

 Paul Pfeiffer's [Applied Probability](#) is a collection for college students versed in basic calculus and looking to learn about the practical aspects of probability. The course guides readers through important probability concepts such as distributions, random variables and functions, variance, and more, using problem sets and guided MATLAB examples.

The Featured Content
portlet

Spotlight and News

The Spotlight portlet provides a rotating set of vignettes highlighting user feedback, author profiles, and important Conneixons announcements. Hear what's going on with the project and what others have to say about it.

SPOTLIGHT



The Connexions Consortium (<http://cnxconsortium.org>) is a group of organizations and individuals, including the world's foremost leaders in education, who work together to advance open source educational technology and open access educational content. Members join the Consortium to work and exchange ideas with other members.

To learn more about becoming a Connexions Consortium member, [click here](#).

The Spotlight portlet showing an announcement

My Account

From the My Account portlet you can log in, request an account, or recover a lost password.

MY ACCOUNT

Username

Password

Log in

▪ [Get an account](#)
▪ [Forgot your password?](#)

The My Account portlet

Find Content

The Find Content portlet provides a convenient, abbreviated version of the content search (a full search also available under the “Content” tab or the search bar in the upper right).

FIND CONTENT

14737 reusable modules woven into 763 collections.

Search Content **Go**

or browse by ...

Subject

Language

Popularity

Title, author, etc.

▪ [Title](#)
▪ [Author](#)
▪ [Keyword](#)
▪ [Revision date](#)

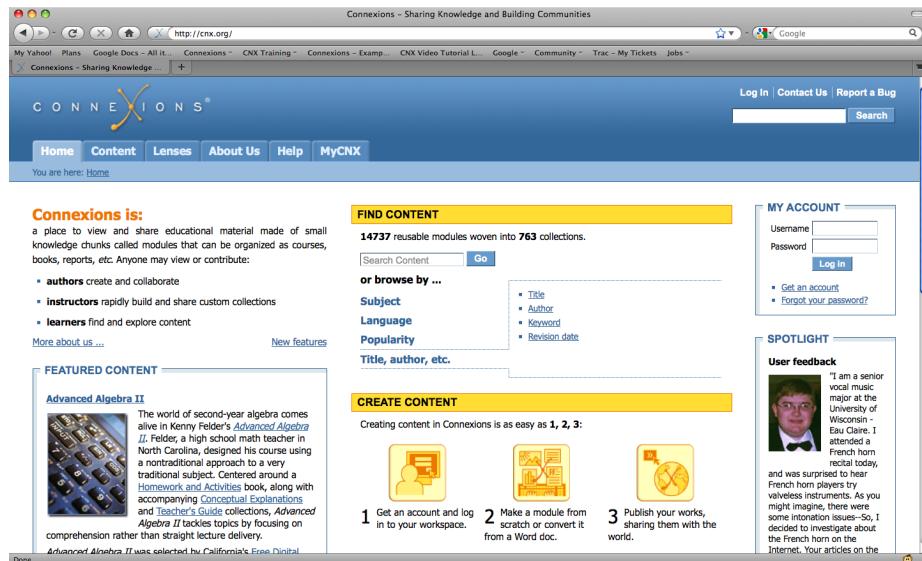
The Find Content portlet

Navigation

The following tabs are used for navigation and appear on every page within Connexions:

Home

The Home tab will return you to the Connexions home page, located at <http://cnx.org/>.



The Home tab

Content

The Content tab directs you to a comprehensive Search and Browse engine for the Connexions content repository. From here you to search or browse by author, title, subject, language, etc.

The screenshot shows the Connexions Content tab interface. At the top, there is a navigation bar with links for Home, Content, Lenses, About Us, Help, and MyCNX. Below the navigation bar, a breadcrumb trail indicates the user is at Home > Content. A message states that content comes in two formats: modules (knowledge chunks) and collections (groups of modules). It also mentions an open license for free use and reuse. The main area is divided into several sections:

- Search for Content:** Includes a search input field, a "Limit search to" dropdown (Title, Author, Collections), and a "Recent Searches" list (mathml [80 matches], emmons autism [1 matches], busbee [163 matches]).
- Browse Content:** This section is highlighted with a yellow border and contains three numbered steps:
 - 1. BROWSE**: A list of browse categories: Subject, Title, Author, Keyword, Popularity, Language, Revision Date, Institution, All Collections. The "Subject" item is currently selected and highlighted with an orange border.
 - 2. REFINE**: A list of refine categories under the "Subject" heading: Arts (Modules: 1074, Collections: 48), Business (Modules: 340, Collections: 22), Humanities (Modules: 1703, Collections: 79), Mathematics and Statistics (Modules: 3124, Collections: 71), Science and Technology (Modules: 3053, Collections: 309), Social Sciences (Modules: 1570, Collections: 80).
 - 3. VIEW**: A placeholder text "Click a link at left first."
- MY ACCOUNT**: A login form with fields for Username and Password, and a "Log in" button. It also includes links for "Get an account" and "Forgot your password?"
- REPOSITORY**: Displays statistics: Total Collections: 763 (Visit a random collection) and Total Modules: 14737 (Visit a random module).
- RECENTLY VIEWED**: Lists recently viewed items under "Collections" (Collaborative Statistics, Connexions Guide to MathML, Fast Fourier Transforms) and "Modules" (Half Steps and Whole Steps).

The Content tab

Lenses

The Lenses tab presents a page listing all public lenses, allowing you to find content that has been endorsed by, affiliated with, or recommended by other Connexions users (the Lenses feature will be described in more detail later in the workshop).

Home Content Lenses About Us Help MyCNX

You are here: Home > Lenses

Public Lenses

Lists of content selected by an organization or individual

Featured lenses

- Siyavula Lenses

Lenses by: Siyavula
Content: 28 lenses



Endorsement lenses

Selections of content that have been carefully checked for quality by the lens maker

- Beyond Traditional Borders

Lens by: Beyond Traditional Borders
Content: 7 modules and/or collections

- CC Open Textbook Project

Lens by: CC Open Textbook Project
Content: 3 modules and/or collections

- Our Americas Archive Partnership's Lens

Lens by: Our Americas Archive Partnership
Content: 13 modules and/or collections

- National Council of Professors of Educational Administration

Lens by: National Council of Professors of Educational Administration
Content: 127 modules and/or collections

MY ACCOUNT

Username
Password

- [Get an account](#)
- [Forgot your password?](#)

PUBLIC LENSES

All lenses

- Endorsements (5)
- Affiliations (12)
- Member lists (47)
- [What's a Lens?](#)



RECENTLY VIEWED

Collections

- [Collaborative Statistics](#)
- [Connexions Guide to MathML](#)
- [Fast Fourier Transforms](#)

Modules

The Lenses tab

About Us

The About Us tab directs you to information about the Connexions project, including our philosophy and mission, project history, sponsors, and so on.

Home Content Lenses About Us Help MyCNX

You are here: Home > About > Philosophy

Philosophy

Community

FAQ

Project History

In the News

Technology

Papers and Talks

Featured Authors

Core Team

Oversight Board

Sponsors and Partners

Related Web Sites

Contact Us

Philosophy

The Connexions approach

Connexions is an environment for collaboratively developing, freely sharing, and rapidly publishing scholarly content on the Web. Our Content Commons contains educational materials for everyone – from children to college students to professionals – organized in small [modules](#) that are easily connected into larger [collections](#) or [courses](#). All content is free to use and reuse under the [Creative Commons "attribution" license](#).

Content should be modular and non-linear

Most textbooks are a mass of information in linear format: one topic follows after another. However, our brains are not linear – we learn by making connections between new concepts and things we already know. Connexions mimics this by breaking down content into smaller chunks, called modules, that can be linked together and arranged in different ways. This lets students see the relationships both within and between topics and helps demonstrate that knowledge is naturally interconnected, not isolated into separate classes or books.

Sharing is good

Why re-invent the wheel? When people share their knowledge, they can select from the best ideas to create the most effective learning materials. The knowledge in Connexions can be shared and built upon by all because it is reusable:

- technologically:** we store content in [XML](#), which ensures that it works on multiple computer platforms now and in the future.
- legally:** the [Creative Commons](#) open-content licenses make it easy for authors to share their work – allowing others to use and reuse it legally - while still getting recognition and attribution for their efforts.
- educationally:** we encourage authors to write each module to stand on its own so that others can easily read it in different contexts and environments. Connexions sites allow instructors to [embed](#) content in their own presentation tools.

MY ACCOUNT

Username
Password

[Get an account](#)
[Forgot your password?](#)

CONNEXIONS NEWS

- Connexions updates interface, adds support for Google Analytics
2009-08-19
- Author Kenny Felder participates in CA Free Digital Textbook Initiative
2009-08-11
- Connexions, Free Textbooks Featured in KHOU's "School Zone" Report
2009-08-04

[More news...](#)

RECENTLY VIEWED

Collections

The About Us tab

Help

The Help tab links to a number of helpful resources, including site feature documentation, author guides, and technical support contact information.

The screenshot shows the Connexions Help page. At the top, there's a navigation bar with links for Home, Content, Lenses, About Us, Help, and MyCNX. Below the navigation, a breadcrumb trail says "You are here: Home > Help > Connexions Help".

Connexions Help

Note: If you're looking for ways to get started viewing Connexions content, you may want to try our [search](#) and [browse](#) features to find what you're looking for.

If you have questions that are not answered by our Help section, please feel free to [contact technical support](#) and we will be happy to assist in any way we can.

Quick help

For Visitors

- [Frequently asked questions](#)
- [Bookmark your favorite content](#)
- [Learn how to rate content](#)
- [Setup your browser to see Connexions math content](#)

For Authors

- [Learn about CNXML](#)
- [Create a module in minutes](#)
- [Create a collection of modules](#)
- [Create a lens of Connexions content \(What is a lens?\)](#)

Guides and Tutorials

Connexions is dedicated to providing its users with the most accurate and up-to-date tutorials. We are constantly updating our documentation modules. Remember, **you can always find the most up-to-date tutorials and guides in the [Connexions Documentation lens](#).**

Please read the [New Author Guide](#) to help you get started entering content into Connexions. For more detailed information and instructions about using Connexions, read the Connexions Tutorial and Reference collection.

MY ACCOUNT

Username
Password

[Get an account](#)
[Forgot your password?](#)

RECENTLY VIEWED

Collections

- Collaborative Statistics
- Connexions Guide to MathML
- Fast Fourier Transforms

Modules

- Half Steps and Whole Steps
- Understanding Basic Music Theory: Course Introduction
- Math Editor Introduction

Lenses

- Connexions Documentation

The Help tab

MyCNX

The MyCNX tab links to the authoring interface. This is the only area of the site you need to log in to your account.

To access this part of the site, you need to log in with your user name and password.

Please log in

Login names are case sensitive. Make sure the caps lock key is not enabled.

Login Name

Password

Log in

[Reset a lost password](#)

Don't have an account?

Viewing content in Connexions doesn't require a login, but free account registration allows you to:

- **Author content**
- **Rate modules** and [let others know what you think](#)
- **Make a lens** of content (including saving to [My Favorites](#))
- **Save your place** when reading through a collection

If you do not have an account here, head over to the [registration form](#).

[Register for an account](#)

RECENTLY VIEWED

Collections

- Collaborative Statistics
- Connexions Guide to MathML
- Fast Fourier Transforms

Modules

- Half Steps and Whole Steps
- Understanding Basic Music Theory: Course Introduction
- Math Editor Introduction

Lenses

- Connexions Documentation
- Susan McClements's Lens

[See all recently viewed...](#)

CONNEXIONS NEWS

- Connexions updates interface, adds support for Google Analytics
2009-08-19

The MyCNX tab

Modules

This module explains the concept of a "module" within the Connexions system. Learners are introduced to the "Lego block" approach to building textbooks, courses, and other learning deliverables through the creation of small, interchangeable learning objects.

Note: See Also:

- Viewing Connexions Content (<http://cnx.org/content/m11836/latest/>)
- About Us/Philosophy (<http://cnx.org/aboutus/>)

You may have noticed that we refer to content as either a 'module' or a 'collection'. You can think of modules like Lego blocks; they come in all different shapes, colors, and sizes, each with a different purpose in mind, and each capable of standing alone or being combined with other pieces.

A module should be designed as a standalone piece of content, usually a single idea or an aspect of a complex idea. Ideally you want to make your module as small as possible without making it dependent on other modules so that other authors can more easily repurpose your work.

Examples of a module can include a chapter of a book, a section from a chapter, a journal article, a lab exercise, a homework assignment, or a daily lesson plan, to name a few.

Take a look at an example module, Half Steps and Whole Steps (<http://cnx.org/content/m10866/latest/>):

This content is ...

Affiliated with [Featured Content](#)

Also in these lenses

- [TEC Music Theory Resources](#)
- [musicBasics](#)

RELATED MATERIAL

Similar content

- [Interval](#)
- [Confidence Intervals: Confidence Interval, Single Population Mean, Population Standard Deviation Known, Normal](#)
- [What is the confidence interval of an estimate?](#)
- [More »](#)

Collections using this module

- [Understanding Basic Music Theory](#)
- [Introduction to Music Theory](#)
- [Beginning Guitar](#)

RECENTLY VIEWED

Half Steps and Whole Steps

Module by: Catherine Schmidt-Jones. [E-mail the author](#)

User rating [\(0 ratings\)](#)

Summary: The pitch of a note is how high or low it sounds. The distance between two pitches can be measured in half steps and whole steps.

The **pitch** of a note is how high or low it sounds. Musicians often find it useful to talk about how much higher or lower one note is than another. This distance between two pitches is called the **interval** between them. In **Western music**, the small interval from one note to the next closest note higher or lower is called a **half step** or **semi-tone**.

Half Steps

(a)

(b)

Links [\[hide\]](#)

Prerequisite links

- [Octaves](#)
- [Pitch](#)

Supplemental links

- [Interval](#)
- [Major Scales](#)
- [Minor Scales](#)

A module in Connexions illustrating the use of links, terms, figures, and subfigures

In this case, the module is a single lesson on the topic of Half Steps and Whole Steps; users coming to this from Google or through a Connexions search will be able to use this module as a standalone unit of learning without relying on any additional modules.

Notice the use of the following Connexions features:

- Links to other resources (internal and external links)
- Terms (can be used as index terms or as glossary terms if definitions provided)
- Figures and Subfigures (note that these - and other - items are automatically numbered and labeled by Connexions)

A **whole tone scale**, a scale made only of whole steps, sounds very different from a chromatic scale.

Whole Tone Scale



Figure 4: All intervals in a **whole tone scale** are whole steps.

[Listen](#) to a whole tone scale.

You can count any number of whole steps or half steps between notes; just remember to count all sharp or flat notes (the black keys on a keyboard) as well as all the natural notes (the white keys) that are in between.

EXAMPLE 1

The interval between C and the F above it is 5 half steps, or two and a half steps.

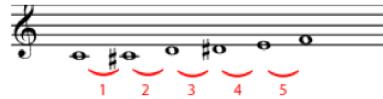


Figure 5: Going from C up to F takes five half steps.

A module in Connexions illustrating the use of media elements and examples

- Multimedia files

Note: Notice the “Listen” link following the Whole Tone Scale figure - this links to a .midi file that is played directly in the browser. In general, if you can embed it or play it in a web browser, you can include it in a Connexions module (assuming your audience’s browsers have the appropriate plug-ins).

- Examples

An exercise with a hidden solution

The same exercise with the solution revealed

EXERCISE 1

Identify the intervals below in terms of half steps and whole steps. If you have trouble keeping track of the notes, use a piano keyboard, a written chromatic scale, or the chromatic fingerings for your instrument to count half steps.



Figure 6

[SHOW SOLUTION]

EXERCISE 1

Identify the intervals below in terms of half steps and whole steps. If you have trouble keeping track of the notes, use a piano keyboard, a written chromatic scale, or the chromatic fingerings for your instrument to count half steps.



Figure 6

EXERCISE 2

Fill in the second note of the interval indicated in each measure. If you need staff paper for this exercise, you can print out this [staff paper](#) PDF file.



Figure 6

SOLUTION

Figure 7

A module in Connexions illustrating the use of an exercise

- Exercises (notice the “Show/Hide Solution” feature)

Here's another example, this time one involving math, covering the topic of Fourier Analysis in Complex Spaces (<http://cnx.org/content/m10784/latest/>):

What is a lens?

This content is ...

In these lenses

- richb's DSP

RELATED MATERIAL

Similar content

- Complex Fourier Series
- Fourier Series and Gibbs Phenomenon
- Complex Fourier Series Data Analysis Using C++ and x86 Inline Assembler
- More »

Collections using this module

- Signals and Systems

RECENTLY VIEWED ▾

TAGS
(?)

- FFT convolution DFT signal processing system CTFT DTFT Fourier

Fourier Analysis in Complex Spaces

Module by: Michael Haag, Justin Romberg. [E-mail the authors](#)

User rating (2): ★★★★★ (0 ratings)

Summary: This module derives the Discrete-Time Fourier Series (DTFS), which is a fourier series type expansion for discrete-time, periodic functions. The module also takes some time to review complex sinusoids which will be used as our basis.

Introduction

By now you should be familiar with the derivation of the [Fourier series](#) for continuous-time, [periodic](#) functions. This derivation leads us to the following equations that you should be quite familiar with:

$$f(t) = \sum_n (c_n e^{j\omega_0 n t}) \quad (1)$$

$$\begin{aligned} c_n &= \frac{1}{T} \int_T f(t) e^{-j\omega_0 n t} dt \\ &= \frac{1}{T} \langle f, e^{j\omega_0 n t} \rangle \end{aligned} \quad (2)$$

where c_n tells us the amount of frequency $\omega_0 n$ in $f(t)$.

In this module, we will derive a similar expansion for discrete-time, periodic functions. In doing so, we will derive the [Discrete Time Fourier Series](#) (DTFS), or the [Discrete Fourier Transform](#) (DFT).

Derivation of DTFS

Much like a periodic, continuous-time function can be thought of as a function on the interval $[0, T]$

A module in Connexions illustrating the use of sections, equations, and MathML

a periodic, discrete-time signal, where $N = 4$:

$$\{ \dots, 3, 2, -2, 1, 3, \dots \}$$

We can represent this signal as either a periodic signal or as just a single interval as follows:

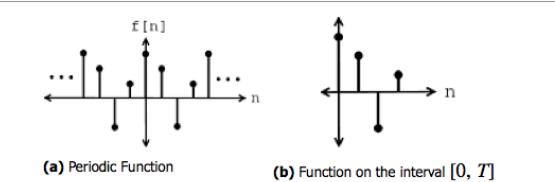


Figure 2: Here we can look at just one period of the signal that has a vector length of four and is contained in \mathbb{C}^4 .

NOTE: The set of discrete time signals with period N equal \mathbb{C}^N .

Just like the continuous case, we are going to form a basis using **harmonic sinusoids**. Before we look into this, it will be worth our time to look at the discrete-time, complex sinusoids in a little more detail.

Complex Sinusoids

If you are familiar with the basic [sinusoid signal](#) and with [complex exponentials](#) then you should not have any problem understanding this section. In most texts, you will see the the discrete-time, complex sinusoid noted as:

$$e^{i\omega n}$$

EXAMPLE 1



A module in Connexions illustrating the use of notes and subsections (nested elements)

This module includes several elements as the previous example, but also includes:

- Sections and Subsections (note the use of nested elements)
- Equations (also numbered automatically by Connexions)
- Notes
- Theorems

THEOREM 1

If we let

$$\forall n, n = \{0, \dots, N-1\} : \left(b_k[n] = \frac{1}{\sqrt{N}} e^{\frac{j2\pi kn}{N}} \right)$$

where the exponential term is a vector in \mathbb{C}^N , then $\{b_k\}_{k=\{0, \dots, N-1\}}$ is an **orthonormal basis** for \mathbb{C}^N .

PROOF

First of all, we must show $\{b_k\}$ is orthonormal, i.e. $\langle b_k, b_l \rangle = \delta_{kl}$

$$\begin{aligned} \langle b_k, b_l \rangle &= \sum_{n=0}^{N-1} (b_k[n] \bar{b}_l[n]) = \frac{1}{N} \sum_{n=0}^{N-1} \left(e^{\frac{j2\pi kn}{N}} e^{-\left(\frac{j2\pi ln}{N}\right)} \right) \\ \langle b_k, b_l \rangle &= \frac{1}{N} \sum_{n=0}^{N-1} \left(e^{\frac{j2\pi(l-k)n}{N}} \right) \end{aligned} \quad (8)$$

If $l = k$, then

$$\begin{aligned} \langle b_k, b_l \rangle &= \frac{1}{N} \sum_{n=0}^{N-1} (1) \\ &= 1 \end{aligned} \quad (9)$$

If $l \neq k$, then we must use the "partial summation formula" shown below:

$$\begin{aligned} \sum_{n=0}^{N-1} (\alpha^n) &= \sum_{n=0}^{\infty} (\alpha^n) - \sum_{n=N}^{\infty} (\alpha^n) = \frac{1}{1-\alpha} - \frac{\alpha^N}{1-\alpha} = \frac{1-\alpha^N}{1-\alpha} \\ \langle b_k, b_l \rangle &= \frac{1}{N} \sum_{n=0}^{N-1} \left(e^{\frac{j2\pi(l-k)n}{N}} \right) \end{aligned}$$

where in the above equation we can say that $\alpha = e^{\frac{j2\pi(l-k)}{N}}$, and thus we can see how this is in the form needed to utilize our partial summation formula.

$$\langle b_k, b_l \rangle = \frac{1}{N} \left(\frac{1 - e^{\frac{j2\pi(l-k)N}{N}}}{1 - e^{\frac{j2\pi(l-k)}{N}}} \right) = \frac{1}{N} \left(\frac{1-1}{1-e^{\frac{j2\pi(l-k)}{N}}} \right) = 0$$

So,

$$\langle b_k, b_l \rangle = \begin{cases} 1 & \text{if } k = l \\ 0 & \text{otherwise} \end{cases} \quad (10)$$

A module in Connexions illustrating the use of a theorem

You may have noticed the use of MathML, a W3C standard language for representing mathematics. This is important because MathML content can be transferred between applications while retaining meaning, is more easily maintained than image files, and is compatible with accessibility features such as screen readers for visually-impaired users.

The screenshot shows a web browser window with the following details:

- Header:** Grab File Edit Capture Window Help
- Title Bar:** Fourier Analysis in Complex Spaces
- Address Bar:** http://cnx.org/content/m10784/latest/
- Toolbar:** Back, Forward, Stop, Home, Refresh, Google search bar.
- Page Content:**
 - Left Sidebar:** "Inline Assembler", "More >".
 - Section:** "Collections using this module" with a link to "Signals and Systems".
 - Section:** "RECENTLY VIEWED" (dropdown menu).
 - Section:** "TAGS" with a question mark icon. Below it are several tags: FFT, convolution, DFT, signal processing, system, CTFT, DTFT, Fourier.
- Main Content Area:**
 - Section:** "Introduction".
 - Text:** "By now you should be familiar with the derivation of the **Fourier series** for continuous-time, **periodic** functions. This derivation leads us to the following equations that you should be quite familiar with:
 - Equation (1):**
$$f(t) = \sum_n (c_n e^{i\omega_0 n t}) \quad (1)$$
 - Equation (2):**
$$\begin{aligned} c_n &= \frac{1}{T} \int_T f(t) e^{-(i\omega_0 n t)} dt \\ &= \frac{1}{T} \langle f, e^{i\omega_0 n t} \rangle \end{aligned} \quad (2)$$
 - Note:** "where c_n tells us the amount of frequency $\omega_0 n$ in"

This image shows the display of MathML content after zooming in to several times the standard font size.